SECTION 2

DESIGNING ASSESSMENTS AND MANAGING INFORMATION

This section discusses several topics related to the overall operation of State water quality assessment programs:

- The extent of individual assessments
- Comprehensively characterizing waters of the State through a combination of targeted and probabilistic monitoring designs
- Delineating waterbodies and watersheds
- Managing assessment data

2.1 Extent of Individual Assessments

The extent or size of a waterbody that is represented by a given monitoring station is important because it affects the quality of assessment results. For example, low assessment quality can result when a large segment of stream or a large lake is assessed based on a single monitoring site. The 305(b) Consistency Workgroup discussed this topic in 1994 and concluded that only general guidance can be given at this time, as follows.

> A monitoring station can be considered representative of a stream waterbody for a distance upstream and downstream that has no significant influences that might tend to change water quality or habitat quality. A significant influence can be
>
> - A point or nonpoint source input to the waterbody or its tributaries
> - A change in watershed characteristics such as land use
> - A change in riparian vegetation, stream banks, substrate, slope, or channel morphology
> - A large tributary or diversion
> - A hydrologic modification such as channelization or a dam.

Because of the importance of site-specific considerations, EPA discourages the use of uniform default values for the size of waterbody represented by a single monitoring site. For streams, States should consider the upstream and downstream characteristics of each monitoring station and its watershed in arriving at an extent of assessment. A single site should not be used to assess an entire watershed unless land use, sources, and habitat are relatively homogeneous (e.g., as is sometimes the case in undeveloped areas) and the observed stressor is consistent with watershed-wide impacts.

In general, a wadable stream station probably should represent no more than five to 10 miles of stream. For large rivers, EPA believes that 25 miles is a reasonable upper limit for a single station unless stream-specific data demonstrate otherwise. However, some large western rivers may have no significant influences for more than 25 miles, as is the case in New Mexico where a few stations on large rivers are believed to represent 50 to 75 miles each.

For lakes, the factors that affect the number of monitoring sites needed per lake are complex. They include purpose of the sampling, lake size, stratification, morphometry, flow regime, and tributaries. No simple guideline for size assessed per station can be given. Reckhow and Chapra (1983) discuss monitoring design for lakes and the potential problems associated with sampling only a single site. Similarly, no specific guidelines are available for the extent of assessment of estuarine monitoring sites. The Washington Department of Ecology (DOE) has used a GIS to draw circles around each monitoring site; the site is considered to represent the area within its circle. Open water stations represent an area within a 4-mile radius, most bay stations represent an area within a 2-mile radius, and highly sheltered bay sites represent an area within a 0.5-mile radius. DOE uses circles in part to emphasize the uncertainty associated with the extent of assessment for estuarine sites.

EPA asks States to provide information in the Assessment Methodology Sections of their 1998 305(b) reports on how they determine extent of waterbody represented by a single assessment or monitoring site.

2.2 Comprehensive Statewide Assessment

EPA, States and Tribes are moving toward a goal of **comprehensively characterizing waters** of the States and Tribes using a variety of monitoring techniques based on the condition of, and goals for, the waters. Achieving this goal would mean a significant increase in the percentage of waters assessed throughout the Nation. For example, in their 1996 305(b) reports, the States assessed approximately 19 percent of the Nation's total stream miles (including intermittent streams, canals, and ditches); this amounted to less than half of the Nation's perennial stream miles. Achieving the goal of comprehensive coverage will require a combination of monitoring approaches including both targeted and probability-based monitoring as well as aggregation of acceptable data from a variety of agencies and sources. Figure 2-1 shows several aspects of monitoring, assessment, and reporting that will be important to realizing the goal.

The traditional means used by EPA to meet the 305(b) requirements has been to compile information from individual States, Territories, Tribes, and interstate basin commissions. In general, such data come from a diverse set of monitoring programs, each of which is based on its own valid purpose. One of the difficulties that arises from this process is differences in overall objectives. On the one hand, EPA is required to report on the condition of the Nation's aquatic resources as a whole, implying either a national census of the resource or a sample survey from which inferences about the entire resource can be drawn. On the other hand, States often select monitoring locations with specific, local purposes in mind. A compilation of such data for regional or national assessments is subject to question about the representativeness of these locations for making comprehensive assessments; i.e., to what extent might the resultant assessment be biased by the non-random selection of monitoring locations as well as the incomplete coverage of the State or Tribal lands?

Comprehensive Assessment: An evaluation of resources that provides complete spatial coverage of the geographic area or resource being studied; it provides information on assessment value (condition of the resource), spatial and temporal trends in resource condition, causes/stressors and sources of pollution, and locational information.

Sample Survey (Probability-Based) Design: A sampling design based on selection of sites or sample locations using some aspect of randomization; allows statistically-valid inferences to be drawn on a population as a whole.

Conventional or Targeted Design: Targeted site selection is used to answer specific questions regarding the condition of a site or area.

Judgmental (Sample Survey) Design: Non-random selection of sampling sites with the intent of using assessment results for drawing inferences on a population as a whole.

Figure 2-1 not available in electronic form

2.2.1 General Types of Monitoring Designs

The section is intended to expand upon these fundamental differences in general objectives; to describe the types of questions each of the monitoring approaches is intended to address and some of the strengths and weaknesses of the approaches; and to provide some initial recommendations toward more comprehensive assessments. The term “sample survey” is used to describe monitoring designs for producing representative data for regional (statewide, basinwide, ecoregional) or national assessments. The term “conventional or targeted” is used to describe monitoring designs that are more local in scope and that tend to focus on a particular problem, or on sites that are selected for a specific local issue. A “judgmental” monitoring design refers to selecting sites for assessing a broader geographic area and assuming that they are representative of that area (non-random selection). EPA recognizes that most States would need to make programmatic or design adjustments in their monitoring efforts to meet national-, regional-, or State-scale objectives as well as more site-specific data needs.

Examples of Monitoring Questions

Site Specific: What is the biological condition of Jamster Creek? (targeted monitoring design most often used)

Regional: What is the biological condition of lakes in the mid-Atlantic coastal plain? (requires probability-based monitoring design or defensible judgmental design in the absence of a census)

Sample surveys are intended to produce snapshots of the condition of an entire resource when that resource cannot be subject to a census (monitoring of every waterbody). Sample surveys rely on the selection of monitoring sites that are representative of the resource. Randomization in the site selection process is one way to ensure that the sites represent the resource of interest. These surveys are often called **probability-based** or statistical sample surveys.

An alternative is to select sites **judgmentally**, based on some criterion other than randomness. Judgmental selection of sites is based on the judgment of the monitoring agency that the sites are representative of the target resource. Such judgmentally-based sample surveys require strong defense regarding the representativeness of the sites so selected, and it may not be possible to estimate the uncertainty with which inferences are made as it is when using probability-based sample surveys.

Targeted designs allow questions to be addressed that are focused on site-specific problems, and the aggregation of these site-specific results to make comprehensive assessments is open to question regarding the representativeness of those sites to the resource as a whole. State monitoring programs that combine aspects of the two general approaches (survey designs and targeted designs) may be necessary to provide data and assessments useful at multiple geographic scales from site-specific to national. Appendix I provides some of the advantages and disadvantages of probability-based, targeted, and judgmental monitoring and also examples of the types of questions that can be addressed by each.

2.2.2 Planning Process for Probability-based Sampling in a Rotating Basin Design

Considerable planning is required to define the particular classes of waterbodies of interest, but the end result can be a cost-effective, defensible and rigorous process for making inferences about all waterbodies in an area.

The initial step in random selection is definition of the target population (e.g., all lakes over 10 acres or all streams of the State). To characterize all streams of a State, basin, or watershed, the agency would do a simple random selection of locations from within the appropriate boundaries (Figure 2-2). However, stream segments could be stratified based on watershed, stream sizes (e.g., first, second, or third-order), ecoregion, or even predominant land use/land cover. Random selection of stream locations for sampling then occurs within each grouping. Figure 2-3 represents the stratification of streams into three classes. Techniques are available to ensure even distribution of sampling sites among the classes or strata and across the resource (or State or basin). The selection process would depend on geographic scale or monitoring questions and objectives. Such a probability-based design can provide assessment data that are useful not only for each class of streams individually, but that can be aggregated into a broader-scale resource assessment. It would also allow

> ***Target Population (Stratum)***: A group of potential sampling locations (or assessment units) that is some subset of the total population of sampling units.
>
> ***Geographic Scale***: Spatial breadth or size; can be based on political unit (e.g., state, county, or municipality), basin or watershed (e.g., the Anacostia River Watershed, the Columbia River Basin), region (e.g., the Huron-Erie Lake Plain ecoregion, the Pacific coastal Mountain ecoregion), or resource (e.g., the Okefenokee Swamp, the Everglades).

extrapolation of sources and causes/stressors to broader geographic scales.

Figure 2-1. Universe of streams from which to draw a random sample

Figure 2-3. Stratification of streams into three classes

(figures not available in electronic form)

2.2.3 Stratified Probability in a Rotating Basin Design

(text box showing schedule not available in electronic form)

Incorporating stratified probability design into a monitoring program could enable a more efficient and effective sampling of all of a State's major basins. If a State is willing to select its order of rotating basins randomly, the State could potentially obtain results, even in the early year(s), that are meaningful and valid for statewide assessment. To apply such a design, begin with a random selection of three to four basins to be sampled in each year (Figure 2-4a). The sampling schedule in the text box above is an example of the results for a State with 16 basins. Randomized selection of basins is not necessary, and the State can select the order of basins on a priority basis.

The second phase of site selection is random selection of stream reaches from within each of the basins. For example, there are 16 stream segments in Basin 6 (Figure 2-4b). Random selection of a subset of stream segments from within Basin 6 allows aggregation of assessment results into a statistically-valid basinwide assessment.

Referring to the above schedule box, following the 1997 sampling season, there would be four basin assessments to aggregate for a statewide assessment; after 1999, there would be 10 basin assessments to aggregate for a statewide assessment, and so forth. With each subsequent year, the confidence associated with statewide assessments increases. In the first year of the second cycle (2002 in this example), the basin rotation would begin again.

> A stratified design can be used to focus on a class of waterbodies for which there has been little previous data collection. For example, larger rivers and streams of some States are well-represented by historical, fixed-station sampling networks, while only a small percentage of headwater streams are assessed. Maryland has applied stratified random design to first- through third-order streams to greatly increase the percentage of its total miles assessed. Delaware selects sampling from all points where roads cross streams.

Figure 2-4a. Random selection of basins

Figure 2-4b. Random selection of streams within a basin

(figures not available in electronic form)

Note: The above is one approach to incorporating probability-based sampling into rotating basin monitoring. Another approach is to use a repeated statewide survey yearly, complimented by targeted monitoring and assessment according to the State's rotating-basin schedule.

EPA/ORD Corvallis is available to provide technical support in designing probability-based rotating basin surveys through coordination with the Regional 305(b) Coordinator. EPA's Environmental Monitoring and Assessment Program (EMAP) has developed expertise in the area of probability surveys and in establishing a mechanism to help States investigate and implement probability-based designs for their specific needs.

2.2.4 Case Studies of Different Types of Monitoring Designs

Probability-based Sample Survey Design: State of Delaware

A probability-based sampling design was developed to assess the ecological condition of Delaware's nontidal streams by the Department of Natural Resources and Environmental Conservation (DNREC). The results were used to produce unbiased estimates of biological and physical habitat condition for the State's 305(b) reports. The area of the State containing nontidal streams was estimated from National Wetlands Inventory data on the State's 35 major watersheds. A list of 3,200 locations where roadways cross a nontidal stream was produced using a GIS. Sampling sites were then selected randomly from this list and sampled during the Fall of 1993. The design was selected to reduce the time necessary to reach specific locations on nontidal streams. The underlying assumption is that road crossings are an accurate representation of nontidal stream resources in Delaware. This assumption is currently being tested.

Ninety-six sites were selected in the northern two counties using this approach; benthic macroinvertebrate and habitat data were collected at all locations. Results of the habitat assessment were presented in Delaware's 1994 305(b) report. The majority of the 1357 miles of nontidal streams in the two counties had impaired physical habitat; 65% were severely impaired (i.e., 'poor') and 22% were moderately impaired (i.e., 'fair'). The habitat results were also reported as three strata within the two counties: one stratum comprising all of Kent County (32 sites); another, the piedmont region of New Castle County (26 sites); and the third, the coastal plain of New Castle County (38 sites). Thus, the probability design allowed reporting of results at two geographic scales: 1) the two counties aggregated, and 2) the two counties individually and separated by physiographic region or topography.

The above description of the Delaware program is taken directly from "The use of a probability-based sampling design to assess the ecological condition of Delaware streams" (Maxted, 1996).

Judgmental Sample Survey Design: State of Washington

This approach is referred to as the 'representative sampling approach' by the staff of the State of Washington, Department of Ecology. They reviewed all existing monitoring stations to determine why existing sampling locations were selected. If stations were selected because they were judged to be representative of the type of water within a watershed, they will be used in the sampling network and aggregated to a statewide assessment. Alternatively, if stations were selected because of their position relative to a known problem, such as those downstream of a specific discharge, they will not be used as part of a statewide assessment. Data from the latter sites will continue to be used strictly for site-specific assessments; the former will provide site-specific assessments that can be aggregated into a regional (statewide, ecoregional) assessment.

All sites determined as appropriate for the statewide assessment will be initially stratified by ecoregion and waterbody type under the assumption that collectively these sites are representative of all waters within their particular stratum. This assumption will be tested by direct comparison to results provided by the strictly probabilistic design of EPA Region 10 REMAP. Although one concern may be that the selection process could be biased against selecting problem sites, preliminary results show an increased percentage of stations exhibiting impairment compared to a strict probability design.

The Washington Department of Ecology provided background material for the above description of their program.

Combined Probability-based Sample Survey and Conventional Designs: Prince George's County, Maryland

The Prince George's County Department of Environmental Resources (DER) recently designed and piloted a county-wide biological monitoring program. The County is located in the middle Atlantic coastal plain region and has flowing surface waters that drain into the Patuxent and Potomac Rivers, which themselves drain into the Chesapeake Bay. The County wants to answer questions at various geographic scales including stream-specific, watershed-wide, and county-wide and to have sampled all watersheds over a 5-year period. It was necessary to be able to have valid county-wide assessments from the first year of the program and to be able to address problems from known point sources.

NPS Monitoring and Evaluation Guide

A nonpoint source (NPS) pollution monitoring and evaluation (M&E) guide is available for use by those who fund and approve M&E plans and those who perform the monitoring. The guide discusses the various objectives of NPS pollution M&E, biological monitoring for NPS pollution, and qualify assurance/quality control aspects, and includes an extensive chapter on statistical methods for the evaluation of NPS pollution monitoring data. Appendices contain abstracts and content listings of over 40 guidance documents related to monitoring both point and nonpoint source pollution programs.

Federal, State and regional agencies that support M&E activities might use the guide to assess the technical merit of proposed plans. Those agencies, private groups, and university personnel that perform M&E might use the guide to formulate their plans. The guide is in no way intended to supersede proven NPS pollution M&E plans currently in use, but it is intended as both a check against existing plans and an outline for developing new NPS pollution M&E plans. To obtain a copy contact the NPS Branch at (202) 260-7110.

The unit of assessment was defined as a channel segment of a wadable, nontidal river or stream into which no tributary flows. The number of assessment units within the County was determined from maps to be approximately 1000. This target population was prestratified (subdivided or grouped) by the following: northern and southern parts of the County, watershed, and order (first through fourth). Step 1 was to randomly select four to five watersheds (alternating between north and south) until about 25 percent of the total population, or 200 stream segments, had accumulated. Then, from within each watershed, approximately 25 percent from each of the groups of first, second, and third order segments were randomly selected. Fourth order segments, if they were represented in a particular watershed, were automatically selected since their occurrence was so rare within the County. This process resulted in a rotating basin design where, over a 6-year period, a total of 254 probability sites would be sampled per index period. Each of the 41 watersheds would have 25 percent of its first order streams sampled, 25 percent of its second order, and 25 percent of its third order.

Twenty to 25 specific streams with known problems or special projects would also be sampled and would be used for evaluating the effectiveness of stream restoration projects, remediation of stormwater outfalls, implementation of BMPs, or the effects of specific discharges.

2.2.5 Improving Monitoring Designs through Modeling

Calibrated empirical and process models hold the potential to estimate in-stream quality based on landscape and other stressor factors. This active area of research links landscape ecology with instream indicators of biological, habitat and chemical quality (e.g., correlating the Index of Biological Integrity with land use and other factors). While probability-based monitoring gives reliable estimates of condition over wide areas, models can provide comprehensive screening for potential problem areas that should be sampled to confirm problems. That is, calibrated empirical and/or process models relating landscape and other stresses to instream condition can potentially provide reliable estimates of where additional problems are likely to be found and thus can result in better targeted monitoring approaches. Statisticians refer to this approach as "model-based inferences." These models may be an additional tool for States in their efforts to use all available monitoring network approaches to answer key questions such as: "what is the desired condition, where are our problems, and are we making progress over wide areas over time?" A potential synergy among approaches is that data from probability-based efforts could be used to construct the models needed for better screening and targeting. References regarding linking landscape ecology with instream indicators of biological habitat and chemical quality include Zucker and White (1996), Roth et al. (1996), Jones et al. (1996), and U.S. Department of Agriculture, 1996.

2.3 Watershed and Waterbody Delineation

The waterbody is the basic unit-of-record for water quality assessment information. That is, most States assess individual waterbodies and store assessment results at this level--results such as degree of use support, causes/stressors, sources, and type of monitoring. The States have defined waterbodies in various ways, from short stream segments and individual lakes to entire watersheds.

The paragraphs below describe features of watersheds and waterbodies and common approaches to their delineation. One goal of this section is to help States make the best decisions about watershed and waterbody delineation, thereby avoiding their need to repeat the process later. Another goal is to ensure that whatever process is selected, it will result in data that can be related to standard watersheds such as USGS Cataloging Units and Natural Resources Conservation Service (NRCS) watersheds to allow data aggregation at various scales. **The proper delineation of individual waterbodies is time-consuming but critically important to a State's 305(b) program. Many States have found it necessary to re-delineate waterbodies after only a few years based on previously unrecognized data needs. EPA urges any State that is considering re-delineating its waterbodies to contact the National 305(b) Coordinator for information about approaches and the experience of other States.**

USGS Hydrologic Units

The Hydrologic Unit Code (HUC) is a system developed by the USGS and adopted as a national standard. This system divides the United States into four levels of hydrologic units for purposes of water resources planning and data management:

- Region (2-digit code)
- Subregion (4-digit code)
- Accounting Unit (6-digit code)
- Cataloging Unit (8-digit code)

Note: NRCS has added two additional levels of watersheds. Figure 1-3 shows an 8-digit USGS Cataloging Unit and a 14-digit NRCS small watershed.

The following illustrations show how the hydrologic unit classification is applied to a portion of the State of South Carolina.

South Atlantic - Gulf Region 03

Figure not available in electronic form

Regions - The Region is the largest unit that USGS uses for comprehensive planning. For example, the South Atlantic-Gulf Region 03 extends from the coastline to the Blue Ridge, and from southern Virginia through the Southeast to New Orleans, Louisiana. There are 18 regions in the conterminous United States, with a national total of 21 (including Alaska, Hawaii, and Puerto Rico and the Virgin Islands).

Subregions and Accounting Units - Subregions are defined by major river basins. For instance, in South Carolina, subregion 0305 includes the Saluda, Broad, and Santee Rivers and the Edisto system. Accounting Units are aggregations of Cataloging Units used by USGS to organize water resource data into manageable units. The South Carolina data in Subregion 0305 are organized into 030501--the Santee, Saluda, Broad Rivers accounting unit--and 030502--the Edisto River accounting unit.

Cataloging Units (CUs) - The CU is the lowest level of hydrologic classification by USGS for planning and data management. There are 2,111 CUs in the continental United States. The 8-digit HUC number designates each individual CU. In the previous graphic, the lines within Accounting Unit 030501 are CU boundaries and each CU has a unique 8-digit HUC.

The HUC has been adopted as a Federal Information Processing Standard (FIPS); i.e., the HUC is a mandatory standard for Federal agencies describing hydrologic data. The HUC classification is well accepted by professional planners and hydrologists at all levels of government and in the private sector.

Figure not available in electronic form

NRCS Watersheds

Years ago, the Soil Conservation Service (now the Natural Resources Conservation Service) subdivided the CUs into watersheds, appending three digits to the eight digit HUC (CU + 3). The designations were made by each State Conservationist to create smaller units for planning activities. There were some consistency problems with the earlier designations, with inharmonious sizes from State to State and a lack of common standards for base maps. Now NRCS Headquarters, working with USGS, EPA, and others, is aggressively pursuing better coherence in the nationwide delineation and standardizing use of the 11-digit watershed code. NRCS is in the process of subdividing States into 14-digit small watersheds (CU + 3 + 3) for planning and analysis at an even finer scale. For example, NRCS in North Carolina worked closely with State environmental agencies to delineate 1,640 14-digit watersheds averaging about 19,000 acres each (see Figure 2-5).

Figure 2-5 not available in electronic form

NRCS 11-Digit Watersheds in Cataloging Unit 03050109

Figure not available in electronic form

NRCS Watersheds as a Common Watershed Base

Many States are seeking to establish common watersheds for use by all State agencies, an approach EPA endorses. The watershed level that seems to offer the most advantages, and is the most frequently chosen by the States, is the NRCS watershed. Use of these watershed boundaries allows easy access to NRCS data and improves coordination of nonpoint source assessments with other agencies.

South Carolina was the first State to index its waterbodies to RF3 and it used the NRCS watershed as the basis for waterbody designation. At first, use support, cause/stressor, and source information was tracked only at the watershed level, but this proved too generalized for use in some specific State decisions. The State then went back and identified use support, causes/stressors, and sources for individual stream segments, which proved to be a useful level of resolution. One goal in any delineation scheme is to assemble data at a resolution sufficient to answer the questions that are important for management, without spending more resources than necessary to obtain data.

South Carolina, on the basis of information developed in its first GIS effort, also developed some important locational information at significantly higher resolution. They used global positioning system (GPS) technology to accurately identify the location of discharges. They are proceeding basin by basin throughout the State. Their GIS now has obvious value as a tool for management.

This type of functionality will become increasingly important as tools such as ArcView become available.* These tools, together with the GIS coverages produced by EPA's Reach Indexing project, will allow States to analyze their waterbody and stream reach data spatially. The WBS route system data model (RTI, 1994) allows the State to geographically identify specific use support classifications down to the reach segment level. The EPA contact for georeferencing waterbodies to RF3 is given on page ii.

Waterbody Delineation

Waterbodies have been defined on a wide range of criteria--from individual RF2 reaches, frequently used from 1986 to 1988, to NRCS watersheds or other groupings conforming to administrative boundaries. Tracking of individual RF3 reaches for the 305(b) report gives detailed resolution to waterbody data but can complicate workload management. On the other hand, watershed-scale waterbodies may fail to give sufficient detail for mapping and management decisions unless they identify the actual locations of use support classifications and causes/stressors and sources of impairment.

EPA recommends that States delineate waterbodies to be compatible with NRCS 11- or 14-digit watersheds. “Compatible” can mean for example that multiple stream and lake waterbodies lie entirely within the watershed’s boundaries but can be mapped individually (i.e., do not cross NRCS watershed boundaries). Where 14-digit watersheds will be delineated in the near future, a State might consider waiting for these boundaries before redelineating waterbodies. Figure 2-5 shows some of the 14-digit watersheds agreed upon by NRCS and the State of North Carolina.

* Mention of trade names in this document does not constitute endorsement. ArcView is a program that enables nonprogrammers to utilize ARC/INFO coverages to do mapping and spatial analysis. ARC/INFO and ArcView (Environmental Systems Research Institute, Inc., ESRI) are the only GIS packages currently in wide use by EPA and State water agencies.

Table 2-1 describes an approach to delineating waterbodies that is consistent with aggregating data at the watershed level. A cornerstone of any approach should be flexible data management. That is, the level of detail of assessment data can vary from watershed to watershed depending on the unique causes/stressors and sources in each watershed. **EPA urges any State that is considering re-delineating its waterbodies to contact the National 305(b) Coordinator for more information about options and experiences of other States.**

Aggregating Assessment Data at Watershed, Basin, and Ecoregion Levels

EPA recommends that States store assessment data at the most detailed level of resolution they can manage—generally at the level of stream segment, individual lake, or very small homogeneous watershed. EPA encourages States to develop the **capability** to aggregate their waterbody-level assessment data to the watershed, basin, and ecoregion levels. EPA is not asking States to present aggregated assessment data by NRCS watershed, USGS HUC or ecoregion in the 305(b) report, but rather to develop the capability to do so by including appropriate locational data. However, if States prepare basin management plans, States are encouraged to begin reporting aggregated data in them (see Appendix E).

Using CUs or NRCS watersheds as basic units for aggregating water quality assessment data will aid in data integration and in making other agencies' data available to the States. Sufficient locational information should be included to allow aggregation of detail at a minimum at the CU level. CU numbers can be stored, for example, in WBS SCRF1 or SCRF2 files. At a minimum, WBS or other State 305(b) databases should contain watershed identification numbers for each waterbody and, to the extent possible, waterbodies should not cross NRCS or CU watershed boundaries. Assessments can also be aggregated by ecoregion if ecoregion codes are stored in WBS for each waterbody, or in combination with a GIS coverage of ecoregions. Note: If waterbodies are georeferenced to RF3, and a GIS is available, aggregation of assessments to watersheds and ecoregions can be done with the GIS.

Reach Indexing Waterbodies to RF3

Reach indexing or georeferencing is the process of electronically linking a State’s waterbodies and other water quality information to the EPA Reach File. Within the next year, RF3 will be incorporated into a new National Hydrography Dataset (NHD), with increased flexibility, accuracy, and GIS compatibility. The NHD will become the official hydrologic database for USGS, EPA, and other agencies. The main product of reach indexing is a GIS coverage containing locations of waterbodies, stream networks and

Table 2-1. Approaches for Delineating Waterbodies

Approach	Description	Advantages, Disadvantages, Comments
Waterbodies include individual stream segments, stream networks, and lakes	Several States use a mix of waterbodies: C mainstem stream segments C individual tributaries or segments C individual lakes C stream networks--tributaries in a small homogeneous watershed can make up one waterbody C lakes in a small watershed can make up one waterbody C individual estuaries or portions of estuaries (polygons) Waterbodies do not cross CU or NRCS watershed boundaries	Provides flexibility in the number of waterbodies and in level of detail State wants to track ARC/INFO route systems and dynamic segmentation can be used to add greater detail for selected waterbodies if needed. States can learn from other States' experiences Ideally, the number of waterbodies should be in a tractable range--recommend keeping the total below 2,000 to 4,000 waterbodies depending on the size of the State With georeferencing to RF3, this approach is powerful in its ability to interface with GIS and EPA databases. For tracking and reporting by watershed, watershed boundaries can be overlaid on these waterbodies using a GIS, or watershed ID numbers can be stored in WBS

flows, and other information. This gives the State powerful mapping and spatial analysis capabilities. In 1996, at least a dozen States incorporated color maps of uses support, causes and sources into their 305(b) reports and other documents such as basin plans. The reaction to this mapping capability has been very positive. Assessment results displayed in map form are much easier for managers and the public to understand than the traditional tabular or printout form.

2.4 Managing Assessment Data

The EPA Waterbody System (WBS) is a PC system of water quality assessment information used by nearly half of the States with 305(b) databases. Most other States have developed and maintain their own customized systems. WBS was developed by EPA for States and other entities specifically for tracking and reporting assessments under 305(b). It provides a standard format for water quality assessment information and includes a software program for adding and editing data, linking to other water databases, generating reports, and transferring data between the PC and GISs.

WBS has four main functions:

- To reduce the burden of preparing reports required under Sections 305(b), 303(d), 314, and 319 of the Clean Water Act
- To improve the quality and consistency of water quality reporting among the States
- To provide data for national level assessments and for analyzing water quality issues outside of 305(b)
- To be a useful water quality management tool for State agencies.

These 305(b) *Guidelines* and user requests determine the features of the WBS. The *Guidelines* require States to track dozens of data types for each waterbody (each State has from several hundred to several thousand waterbodies) in order to generate the summary tables required in Section 4 of the main volume of these *Guidelines*. Although most WBS features result from the 305(b) *Guidelines*, WBS also contains some data elements that States have requested for internal management purposes (e.g., georeferencing fields and memo fields).

WBS contains over 100 data elements in such categories as:

- Descriptors — waterbody name, number, description, type (stream, lake, etc.), size

- Locational data elements — Reach File coordinates, basin and watershed identifiers

- Assessment data — degree of use support for each use, size impaired, causes/stressors and sources, type of monitoring, type of assessment, assessment confidence.

For detailed information about the WBS, see the *WBS Users Guide*. EPA also provides ongoing technical support to WBS users. Between January and August 1996, EPA provided consultations to more than 30 agencies, including States, Territories, Tribes, and Interstate Commissions, on the use of WBS and RF3 for 305(b) programs. Contact WBS Technical Support at the telephone number on page ii.

Data Management Options for Aggregating Data by Watershed

At least three options are available for aggregating assessment data by watershed for basin management plans and other purposes. These options are compatible with WBS and the approaches described in Table 4-1.

1. <u>Entirely within WBS or other State assessment database</u>. If waterbody records contain CU or NRCS watershed numbers, the database can aggregate data to that level automatically.

2. <u>WBS or other State assessment database in combination with a GIS program</u>. WBS can be used to store assessment data in combination with GIS programs such as ARC/INFO or ArcView, which enable users to analyze spatial data and prepare maps. ArcView runs on personal computers and users do not need to learn the ARC/INFO programming language. It uses standard ARC/INFO data coverages (e.g., reach-indexed waterbodies or STORET monitoring stations). (See previous note regarding mention of trade names.)

3. <u>Entirely within the GIS environment</u>. States with full GIS capability (e.g., having access to ARC/INFO programmers and workstations) can manage assessment data within the GIS environment and export results to WBS or other programs for reporting.